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POST ANTHESIS NITROGEN LOSS FROM CORN

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Introduction

Nitrogen (N) management practices of corn producers have been called into question because of nitrate contamination problems in surface and ground water. Fertilizer N has been strongly implicated as the major source of much of the nitrate that now exists in our water resources. Cultural practices used in corn production lend themselves to possible nitrate leaching because practical limitations require a majority of the fertilizer N to be applied well ahead of when it can be used by the crop.

Nitrogen uptake by corn is anything but uniform throughout the growing season. Little N is used by a corn crop before mid June and by silking in mid to late July 70 to 90% of total N uptake at harvest will already be in the plant. This scenario implies that only 10 to 30% of total N uptake occurs after silking even though the crop accumulates about half of its dry matter after silking. This simple analogy assumes that once N enters the plant it is not lost until the crop matures.

Volatile N Losses

The contribution of N fertilizer toward increasing crop productivity are well documented, but our knowledge of the various ways N can be lost from the soil-plant system and the associated environmental impacts is quite fragmented. Some pathways for N loss have been known for decades, while others have only recently been recognized. Calculations for N fertilizer use efficiencies are typically based on the amount of N found in the crop at maturity. It is commonly perceived that maximum accumulation of N by plants occurs at maturity, but in fact, it is more typical for maximum N accumulation of many grain crops to be reached sometime between pollination and maturity. Agronomists have been aware for some time of numerous reported instances where the total amount of N in the aboveground parts of grain crops actually decreased before maturity. In cases where the total amount of N in the crop decreases before maturity or even when it remains static, the questions become; 1) Did the crop cease taking up N during grain fill? 2) If N uptake

continues, why doesn't total N in the plant continue to increase? 3) What is the pathway and fate of any N lost from living plants?

Published research over the last decade has shown relatively large amounts of volatile N compounds (mainly NH_3) can be lost from aboveground vegetation of various grain crops. These losses mainly occurred during grain development. Reported volatile N losses have been as high as 69 lb/A for winter wheat and 40 lb/A for soybean. Generally, N losses increased as the amount of applied fertilizer N increased.

Under favorable growing conditions, many corn hybrids achieve maximum N accumulation between silking and the grain's milk stage. During kernel fill, large amounts of N can be translocated from vegetative tissue to the grain. One method of monitoring N translocation to the grain and determining if additional N is being taken up from the soil is by the use of isotopically labeled N fertilizer. Isotopic techniques provide a means for differentiating and tracing N coming from the various sources (soil, fertilizer, etc.). By being able to trace its fate, the interactions of labeled N within the soil-plant system can be studied.

Nitrogen balance studies using isotopically labeled N have been a valuable aid in expanding our knowledge of N interactions in various cropping systems. In labeled N balance studies it is common to have 5 to 25% of the applied fertilizer missing or unaccounted for from the soil-plant system at the end of the growing season. Previously, leaching and volatile N losses from the soil, mainly thought to be associated with denitrification, were assumed to be major reasons for this missing N. Recent findings indicating that substantial N loss can occur from plant tops do not translate into increased amounts of N being lost from soil-plant systems. Rather, these data identify another mechanism to explain some of the unaccounted for N loss noted above.

One objective of our study was to quantify, under field conditions, N loss from corn plants during grain fill. Two irrigated corn studies, which had labeled N fertilizer applied, were used to determine the amount and location of labeled N in the aboveground plant parts. At site 1, fertilizer applications of 45, 89, and 134 lb/A of N were applied at the three leaf stage as labeled NH_4NO_3 to Stauffer S7767 corn hybrid. The total amount of N in the corn plants reached a maximum at the blister stage and remained constant for all treatments through maturity. However, for the three labeled treatments, isotope data showed that 15, 17, and 20% of the labeled N that was in the plants at the blister stage was missing by maturity. If one assumes that non-labeled N is lost at the same time and rate as labeled N, then total N losses from the aboveground plant material for the three treatments was 44, 49, and 70 lb/A of N (Figure 1). Net N in the plant tops remained constant after the blister stage for these plots, which means that similar amounts of N were taken up as were lost during the final 55 days of grain fill.

At site 2, labeled N treatments of 67, 134, 201, and 268 lb/A were applied at the six leaf stage to Pioneer brand hybrid 3379. In this case maximum N accumulation occurred when the grain was at the milk stage. For the three highest fertilizer rates, total plant N decreased before maturity was

achieved. Labeled N losses from the plant tops across the four N rates ranged from 6 to 31 lb/A, which extrapolates to total N losses of 40 to 72 lb/A. All four fertilizer treatments showed that less than half of the labeled N that left the leaves and stalks between the milk stage and black layer development was translocated to the grain (Table 1).

The mechanism and reasons why volatile N losses occur from plant is not understood. Some researchers attribute N losses mainly to inefficient N translocation and reassimilation within the plant. However, this does not explain why large losses are noted in some studies while negligible amounts are only detect in others. Research is needed to determine which environmental and physiological factors affect or control N loss processes. Nitrogen availability and moisture stress are two factors which appear to affect these processes.

It may seem inconsequential whether N losses are coming from the soil or plants, but it becomes important as we continue to look for ways to improve N fertilizer use efficiencies. For example, failure to consider volatile plant N losses will result in overestimation of N losses from the soil by denitrification and leaching. Proper accounting of all N losses from the soil-plant system is needed to fully assess each loss component. This information is necessary as we attempt to develop appropriate means to improve N fertilizer use efficiencies and to properly evaluate any proposed new management strategies.

References

- Francis, D. D., Schepers, J. S., and Vigil, M. F. 1993. Post-anthesis nitrogen loss from corn plants. *Agron. J.* 85:659-663.